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Evaluation of Rhizoma Peanut Genotypes for Adaptation in Texas

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ABSTRACT

Rhizoma peanut (*Arachis glabrata* Benth.) is a warm-season perennial forage legume adapted to the extreme southern USA. The objectives of this study were to compare the establishment rate and overall adaptation of 'Florigraze', 'Arbrook', PI 262819, and PI 262821 rhizoma peanut in south and north-central Texas. Two separate field experiments were initiated to evaluate establishment rate and adaptation of rhizoma peanut. In the first experiment, the rate of establishment was documented by measuring shoot appearance in parallel zones equidistant from the original planting. In the second experiment, shoot spread (distance to farthest shoots) was measured 26 mo after planting and dry matter (DM) yield was estimated 1, 2, and 4 yr after planting in south Texas. In 1991, a dry year, PI 262819 had a greater number of total shoots in June and shoots in the zone farthest from the original planting in June and September compared with other genotypes. In 1992, Florigraze, PI 262819, and PI 262821 did not differ from each other in total shoot counts or counts within each zone; however, all were superior to Arbrook. In the second experiment, spread was greatest among genotypes for PI 262821 in south Texas, and for PI 262819 in north-central Texas. Total DM yield in south Texas was greatest for Arbrook the first season after planting; however, there were no differences in yield between genotypes in subsequent years. Rate of establishment and adaptation of PI 262819 and PI 262821 were equal to or better than Florigraze and Arbrook in both south and north-central Texas.

RHIZOMA PEANUT is a warm-season perennial forage legume adapted only to the extreme southern USA, due to its limited winter hardiness (French and Prine, 2006). Rhizoma peanut has relatively high DM yield and nutritive value, similar to that of alfalfa *(Medicago sativa* L.) (Ocumpaugh, 1990; French, 1991). Terrill et al. (1996) reported that alfalfa had greater crude protein levels than rhizoma peanut, but in vitro organic matter digestibility values were similar. Saldivar et al. (1990) reported crude protein concentrations ranging from 200 to 250 g kg^{-1} in April, but declined to 125 g kg^{-1} at the end of the season. In Florida, the DM yield of 'Florigraze' and 'Arbrook' range from 10 to 12 Mg DM ha^{-1} (Prine et al., 1986a, 1990). In central Georgia, Florigraze yields increased from 5.2 Mg ha^{-1} the season after establishment to 10.6 Mg ha^{-1} the third season after establishment (Terrill et al., 1996). In south Texas, (Ocumpaugh, 1990), Florigraze DM yields (8–12 Mg ha^{-1}) were similar to yields obtained in Florida and Georgia. In north-central Texas, PI 262821 yields averaged 6 Mg DM ha^{-1} under dryland conditions and 10 Mg DM ha^{-1} under irrigation (T. Butler, unpublished data, 2005). Several studies have reported that rhizoma peanut does not respond to increased levels of soil P and K (Prine et al., 1986a, 1990; Niles et al., 1990). Roots were found to exceed 3-m depth and have been implicated in the lack of response to added nutrients (French et al., 1993).

Rhizoma peanut has been grown in areas of Texas infested with cotton root rot (*Phymatotrichum omnivorum* Duggar), where alfalfa was killed (W. Ocumpaugh, personal communication, 2005). Cotton root rot, also known as Texas root rot, is a naturally occurring fungal pathogen found throughout Texas and southern Oklahoma. Rhizoma peanut has been documented to be infested with cotton root rot (Barnes, 1990). Infected areas appear as circular patterns throughout the field where the rhizoma peanut initially dies back. Florigraze is able to recolonize these areas the next year due to its rhizomatous growth pattern, while Arbrook suffers greater losses from cotton root rot (French et al., 1993), possibly due to a slower rate of rhizome spread. Identification of locally adapted material could prove beneficial by adding high-quality forage during the summer, especially in areas where alfalfa is not well adapted.

Rhizoma peanut is typically only recommended for sandy soils with a pH ranging from 5.8 to 6.5 (Prine et al., 1990; French and Prine, 2006). Establishment and DM yield of Florigraze rhizoma peanut on sandy soils in Florida was negatively correlated with increasing levels of soil pH from 5.2 to 7.9 (Niles et al., 1990). Reed and Ocumpaugh (1991) reported the identification of 23 genotypes made from a population of 69 PIs, based on tolerance to Fe deficiency chlorosis on high-pH soils associated with calcareous soils. Of these 23 genotypes, two (PI 262819 and PI 262821), originally from Paraguay (French et al., 1993), were identified as having agronomic potential with greater height, spread, and estimated DM production.

Although rhizoma peanut has potential to provide high-quality forage during the summer when forage quality is typically low, it requires 2 to 3 yr for complete coverage (Rice et al., 1996; Williams et al., 1997). Defoliation the season before digging sprigs reduces total nonstructural carbohydrates (TNC), N, and rhizome mass (Rice et al., 1995). Planting rhizomes with initial TNC $\geq$ 228 g kg^{-1} resulted in greater rhizome and shoot mass during the establishment year since these plants had faster growth rates, especially during drought conditions (Rice et al., 1995). Another weakness of rhizoma peanut is the high cost of planting along with the long grazing-deferment period during establishment. Defoliation during the year after establishment greatly reduces rhi-

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Abbreviations: DM, dry matter; MAP, months after planting.

zome production (Saldivar et al., 1992), therefore utilization needs to be deferred until stands are completely established. Identifying germplasm that establishes more rapidly than the currently available genotypes might expand the area where rhizoma peanut is grown. There is a large area of Texas (throughout the central and western parts) as well as other areas around the world where high-pH soils are common. Some of these regions have the potential to grow rhizoma peanuts if the appropriate plant material was available. The genotypes selected for improved agronomic traits may be better adapted to Texas than the current cultivars from Florida. Therefore, the objectives of this study were to compare the establishment rate and overall adaptation of 'Florigraze', 'Arbrook', and two selected genotypes (PI 262819 and PI 262821) of rhizoma peanut in south and north-central Texas environments.

MATERIALS AND METHODS

Two separate field experiments were conducted in Texas to evaluate rhizoma peanut. The first randomized complete block design experiment with 10 replications was planted in each of 2 yr (1991 and 1992) on adjacent sites at the Texas Agricultural Experiment Station at Beeville (28°N, 97°W, altitude 155 m). The second randomized complete block design experiment was conducted at two locations (Beeville and Stephenville [32°N, 98°W, altitude 395 m]) in April 1993 with four replications at Beeville and two replications at Stephenville. In both experiments, treatments included four rhizoma peanut genotypes: two unreleased genotypes (PI 262819 and PI 262821) and two released genotypes (Florigraze and Arbrook).

Experiment 1

In the first experiment, the initial soil test on the Parrita sandy clay loam soil (clayey, mixed, active, hyperthermic, shallow Petrocalcic Paleustoll) indicated a pH of 6.7, 12 mg P kg^{-1}, and 172 mg K kg^{-1}. The area was fertilized with 51 kg P_2O_5 ha^{-1} in the form of diammonium phosphate (18–46–0) the season before initiation of the establishment experiment. Total plot size was 1 by 2 m, with 1-m alleys between plots. Each year, 40 g of freshly dug rhizomes were planted approximately 4 cm deep in a single row or "trench" approximately 10 cm wide by 31 cm long on 27 Mar. 1991 and 3 Mar. 1992. Rhizomes were evenly distributed throughout the trench and granular peanut inoculum (Nitragin Inc., Brookfield, WI) was applied before covering. The plot areas were fenced each year to prevent herbivory from jackrabbits (*Lepus californicus* Gray). In 1991, soil moisture was limiting (Fig. 1); therefore plots were supplemented with 50 mm of irrigation 60 d after planting. In 1992, plots were not irrigated since there was adequate soil moisture. Weeds were controlled by hand weeding and herbicide applications of a tank mix of 0.4 kg a.i. ha^{-1} fluazifop-P-butyl (butyl (*R*)-2-[4-[[5-triflouromethyl)-2-pyridinyl]oxy]phenoxy]propanoate), 0.28 kg a.i. ha^{-1} 2,4-DB [4-(2, 4-dichlorophenoxy)butyric acid, dimethyl amine], 0.56 kg a.i. ha^{-1} acifluorfen (5-[2-chloro-4-(trifluromethyl)phenoxy]-2-nitrobenzoate), 0.56 kg a.i. ha^{-1} bentazon [(3-1-methylethyl)-1H-2,1,3,benzothiadiazin-4(3H)-one 2,2 dioxide], and 0.3 kg a.i. ha^{-1} paraquat (1,1′-dimethyl–4,4′-byridinium dichloride) as needed throughout the growing season.

In the first experiment, shoots were counted three times throughout the season of establishment (first year). In the 1991 planting, total shoots were counted on 13 June for the entire plots, and shoots within five 12-cm zones parallel to the original trench were counted on 26 August and 26 November. In the 1992 planting, emerged shoots were counted for the entire plot on 16 June and for the 12-cm zones on 2 September and 3 October. Shoots by zone were not differentiated early in the season since most of the shoots originated from the initial trench (Zone 0).

Experiment 2

In the second experiment, the soil for the Beeville location experiment was a Weesatche sandy clay loam (fine-loamy, mixed, superactive, hyperthermic Typic Argiustoll), with an initial soil test pH of 7.4, very low soil P, and very high soil K. This location was fertilized with 103 kg P_2O_5 ha^{-1} in the form of diammonium phosphate 2 wk before planting. Plots were sprayed with 0.07 kg a.i. ha^{-1} ammonium salt of imazethapyr [(±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imi-

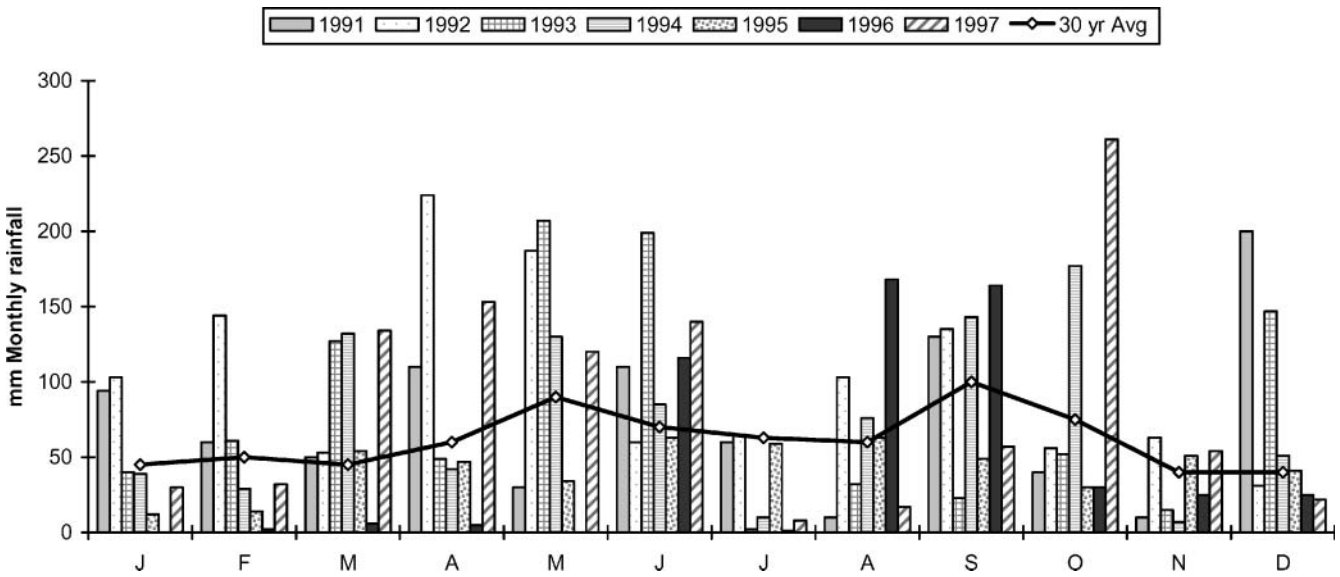

Fig. 1. Monthly precipitation during 6-yr and 30-yr average trend line at Beeville, TX.

dazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid] and 2.7 kg a.i. ha^{-1} acetochlor [2-chloro-*N*-(ethoxymethyl)-*N*-(2-ethyl-6-methylphenyl)acetamide], which was incorporated to the 5-cm depth before planting. Plot size at Beeville was 2 by 5 m, with 5-m alleys between genotypes within replications and 9-m alleys between replications. Plots were designed much larger than needed to permit future digging of sprigs once the yield data was collected. The planting at Beeville was established with two rows of five greenhouse-grown potted plants (15-cm pots) with 1-m spacing between rows and among plants within the row. Plants were hand watered the day of planting (20 Apr. 1993) and again 3 d after planting. On 3 May 1993, low-vigor plants were replaced with vigorous plants and hand watered. Plots were sprayed with 0.7 kg a.i. ha^{-1} fluazifop on 13 Apr. 1994, 25 Aug. 1994, and 28 June 1996. At Beeville, spread was measured at three points in each plot as the maximum distance of shoot appearance across the entire plot. These plots were harvested for DM yield during the 1994, 1995, and 1997 growing seasons. Plots were not harvested in 1996 due to limited growth associated with little rainfall.

In the second experiment at Stephenville, the soil type was a Windthorst sandy loam soil (fine, mixed, active, thermic Udic Paleustalf), with an initial soil test pH of 5.1, 6 mg P kg^{-1}, and 205 mg K kg^{-1}. This location was fertilized with 56 kg P_2O_5 ha^{-1} in the form of triple superphosphate, which was incorporated before planting. Plots measuring 1 by 5 m, with 2-m alleys between plots, were permanently marked with steel posts. A single row of five greenhouse-grown potted plants with 1-m spacing between plants within the row were planted on 9 Apr. 1993. Plants were hand watered immediately after transplanting; however, plots were not sprayed with herbicides. Plant survival and distance of spread were measured twice at 26 and 28 mo after planting (MAP). Plots at Stephenville were left alone and the percentage of the stand within the permanently marked plots was evaluated 10 yr after planting to determine long-term survival of these plots.

Parameters evaluated as dependent variables include shoot count (total or by zone), spread, and DM yield, while location, year, replication, genotype, and sampling date were considered independent variables. Data were subjected to analyses of variance using PROC GLM (SAS Institute, 1999) with treatment differences less than $P = 0.05$ reported as significant. Means, where appropriate, were separated using Fisher's Protected LSD test at the $P = 0.05$ level of significance.

RESULTS AND DISCUSSION

Rhizoma Peanut Shoot Counts (Experiment 1 Only)

Year × genotype, year × sampling date, and genotype × sampling date interactions were significant ($P < 0.05$) for shoot counts, therefore means are reported by year and by sampling date. Shoot counts in 1992 were greater than in 1991 (Table 1). This difference could be related to an earlier planting date in 1992, but it is more likely due to the increased rainfall in 1992 (Fig. 1). In 1991, Arbrook had fewer total shoots than the other genotypes at all three sampling dates (June, August, and November). Arbrook also had the fewest shoots in each of the zones away from the original planting at both the August and November sampling dates, indicating that it was the slowest to establish. French and Prine (2006) also reported that Arbrook was slower than Florigraze to establish in Florida. There were no consistent differences in total shoot counts between PI 262819, PI 262821, and Florigraze, although PI 262819 had more total shoots in June 1991 and greater shoot counts in Zone 4 (farthest from original planting) in August and November. The greater number of shoots in Zone 4 could mean a faster rate of spread for PI 262819 in 1991, the lower rainfall year.

In 1992, Arbrook again had the lowest number of total shoots for the June and September sampling dates, and it had fewer total shoots than PI 262819 and PI 262821 in October. Arbrook had fewer shoots in September and October within Zones 1 through 4, indicating that it was the slowest to establish and could be more susceptible to weed competition. There were no consistent differences for total shoot counts or shoots within zones for PI 262819, PI 262821, and Florigraze. This indicates that these genotypes may not have greater spread than Florigraze in higher rainfall areas. The main advantage with these unreleased genotypes would be greater spread in lower rainfall regions, in addition to superior tolerance to Fe deficiency chlorosis on high-pH soils (Reed and Ocumpaugh, 1991).

Table 1. Total shoot counts and shoot counts by zone of rhizoma peanut at Beeville, TX, during the 1991 and 1992 growing seasons.

Genotype	Total	Zone 0	1	2	3	4	Total	Zone 0	1	2	3	4	Total
	no. shoots												
	1991†												
	13 June	26 Aug.						26 Nov.					
262819	20.0	20.8	4.6	3.6	3.1	3.3	35.4	23.3	12.2	9.6	8.6	9.7	63.4
262821	11.3	15.8	6.6	2.7	4.2	1.9	31.2	18.5	13.0	9.7	7.4	6.7	55.3
Florigraze	13.7	18.9	4.9	2.5	0.9	0.3	27.5	26.7	20.3	11.6	8.3	3.1	70.0
Arbrook	1.8	6.7	1.4	0.6	0.0	0.0	8.7	13.4	5.4	0.9	1.1	0.0	20.8
LSD‡	3.3	3.9	3.3	3.0	2.5	1.9	8.9	6.7	5.1	5.4	4.1	5.9	17.8
	1992§												
Genotype	16 June	2 Sept.						3 Oct.					
262819	28.6	27.2	21.2	2.5	0.1	0.0	51.0	33.9	36.0	14.8	13.2	5.5	103.4
262821	32.1	29.0	17.2	5.2	3.6	0.9	55.9	37.5	34.8	19.9	19.9	8.8	120.9
Florigraze	31.4	34.7	28.2	4.5	2.3	0.2	69.9	48.1	40.5	16.4	16.5	6.6	128.1
Arbrook	19.3	24.5	14.9	2.1	0.6	0.0	42.1	42.3	36.3	11.0	4.4	0.3	94.3
LSD‡	7.2	NS	9.2	3.3	1.7	0.6	15.5	NS	NS	6.0	7.9	4.0	30.1

† Rhizoma peanuts were planted on 27 Mar. 1991.
‡ Least significant difference at the $P = 0.05$ level of significance; NS = not significant.
§ Rhizoma peanuts were planted on 3 Mar. 1992.

Rhizome Spread and Survival

Experiment 1

Year × genotype interactions were not significant ($P > 0.05$), therefore data were pooled across years. There were no differences in survival; however, there were differences in distance of spread when evaluated 5, 8, and 12 MAP (data not shown). Genotypes PI 262819 and PI 262821 had the greatest distance of spread for all sampling dates and averaged 48 and 52% greater distance of spread than Florigraze and 82 and 86% greater spread than Arbrook (data not shown).

Experiment 2

Location × genotype interactions were significant ($P < 0.05$); therefore means are reported by location. At Beeville, there were no differences in survival (100%), which is expected since these plots were irrigated at planting and low-vigor plants were replaced (Table 2). The distance of spread 26 MAP was greatest for PI 262821 followed by PI 262819, then Florigraze, and then Arbrook at Beeville. At Stephenville, PI 262819 and PI 262821 were superior to Arbrook in survival, while Florigraze survival was vastly inferior (Table 2). Prine et al. (1990) and French and Prine (2006) reported that emergence and survival of Arbrook following planting into dry soil conditions were superior to Florigraze, which would agree with this experiment. The spread of rhizomes (as indicated by shoot emergence) 26 MAP at Stephenville was greatest for PI 262819. Florigraze and PI 262821 were similar in spread while Arbrook consistently had the least spread. This indicates that PI 262821 and PI 262819 have the potential to spread farther and survive better than the currently available genotypes in these drier regions.

Stephenville, TX, is considered to be too far north to grow rhizoma peanut (French and Prine, 2006). After 10 yr, undefoliated plots at Stephenville were rated for long-term survival. Genotypes PI 262819 and PI 262821 maintained 100% coverage within the permanently marked steel posts and spread into adjacent plots, while Florigraze and Arbrook had <2% coverage (data not shown). In newly established increase blocks of PI 262819 and PI 262821, plants survived temperatures down to −15°C on 8 Dec. 2005 at Stephenville, TX, and Ardmore, OK, indicating that these genotypes may be grown farther north than previously recommended (French and Prine, 2006). These two genotypes may be more tolerant to cotton root rot or drought, or may have increased cold tolerance to survive at this northern location, but this needs to be confirmed with additional research. Ball et al. (2002) reported that Florigraze can survive temperatures down to −9°C, and Terrill et al. (1996) reported that Florigraze survived −12°C in central Georgia (32°N, 83°W). Prine et al. (1986b) reported winter kill of rhizoma peanut in southern Georgia that was harvested four times the second season after establishment, but uncut plots had no winter stand loss. The severity of winter during the first winter following establishment can also have a major influence on rhizoma peanut survival (C. Simpson, personal communication, 2005). Apparently the initial winter conditions and harvest management during establishment (2 yr) can greatly affect rhizoma peanut survival.

Table 2. Rhizoma peanut spread and survival at the Beeville and Stephenville, TX, locations in the second experiment.

	Beeville†			Stephenville†		
Genotype	Survival	14 MAP‡	26 MAP	Survival	26 MAP	28 MAP
	%	cm		%	cm	
262819	100	196	509	100	248	288
262821	100	197	572	100	207	258
Florigraze	100	191	412	30	192	233
Arbrook	100	142	307	70	171	220
LSD	NS	18	28	10	30	33

† Spread at Beeville from two rows of potted plants 1 m apart, and at Stephenville from one row of potted plants.
‡ Months after planting.

Dry Matter Yield (Experiment 2 Only)

Year × genotype interactions were significant ($P < 0.05$); therefore, DM yields are reported by year (Table 3). In the year after planting, Arbrook produced the greatest amount of DM, followed by Florigraze, then PI 262819, and then PI 262821. Arbrook produced 28% greater yield than Florigraze and 73% more DM than PI 262821. It appears that Arbrook initially allocates more energy into shoot growth, whereas PI 262819 and PI 262821 allocate their resources to producing greater rhizomes, which could be the reason for greater spread with these two genotypes. There were no differences in yield among all four genotypes in subsequent years of evaluation, when plants were considered to be established. Yield ranged from 7.9 to 16.0 Mg ha^{-1} yr^{-1}, which is similar to previous reports by Prine et al. (1990) and Ocumpaugh (1990). This illustrates that genotypes PI 262819 and PI 262821 are as productive as commercially available genotypes.

CONCLUSIONS

The two genotypes (PI 262819 and PI 262821) appear to be superior at establishing and spreading in Texas, which receives less rainfall and lower winter temperatures than where rhizoma peanut has been previously grown in the USA. In addition, these genotypes are equal in total DM production to Arbrook and Florigraze. Genotypes PI 262819 and PI 262821 should be evaluated further to determine if rhizoma peanut can be

Table 3. Dry matter (DM) yield of rhizoma peanut in Exp. 2† at Beeville, TX, during the 1994, 1995, and 1997 growing seasons.

Genotype	1994	1995	1997
	Mg DM ha^{-1}		
262819	10.4	9.4	11.5
262821	9.5	7.8	13.4
Florigraze	12.8	7.9	13.9
Arbrook	16.4	8.3	12.0
LSD	2.7	NS	NS

† Exp. 2 was planted in 1993; 1996 was not harvested due to extreme drought and little growth.

successfully grown in Texas as an alternative to alfalfa. These two genotypes were previously identified as having superior tolerance to high-pH soils that are prevalent in much of western and central Texas, and if the superior winter hardiness continues with additional testing, then these two genotypes should be considered for further evaluation and potential release for use in south and central Texas and perhaps into northern Texas and southern Oklahoma.

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